

Network Warfare Simulation (NETWARS) VV&A Efforts

SPAWAR Systems Center San Diego (SSCSD)
Code 2822

Background

- Who We Are
 - SPAWARSCEN 2822 (Network Centric Warfare Analysis Branch)
 - Support Navy Modeling and Simulation Management Office (NAVMSMO), OPNAV N61-M, and N61-F, for Joint C4ISR Communication M&S assessment domain
 - Supporting Communication M&S for 10 years.
 - Lead Navy NETWARS developers
- What We Do
 - Perform C4ISR communication system performance analyses.
 - Modeling and Simulation (M&S) is our most commonly used assessment method.

SSCSD M&S Study Areas

- Capacity Planning/Scalability
- Technology Impact
- Acquisition
- Prototype development and assessment.
- Operational Decision Aids/Doctrine development
- Training
- Co-simulation

SSCSD M&S Capabilities and Resources

- Simulation Tools
 - Naval Simulation System (NSS)
 - NETWARS/OPNET
 - Qualnet
- Existing Communications Model Library
 - COTS and GOTS protocols, devices and systems.
 - OPNAV N61-M C4ISR models
- Scenario and Traffic Data models
 - Navy Defense Reference Model (DRM)
 - Operational scenarios validated by Office of Naval Intelligence
 - Probe and Information Exchange Requirements (IER) data.
 - Import real probe traffic data into modeled networks.

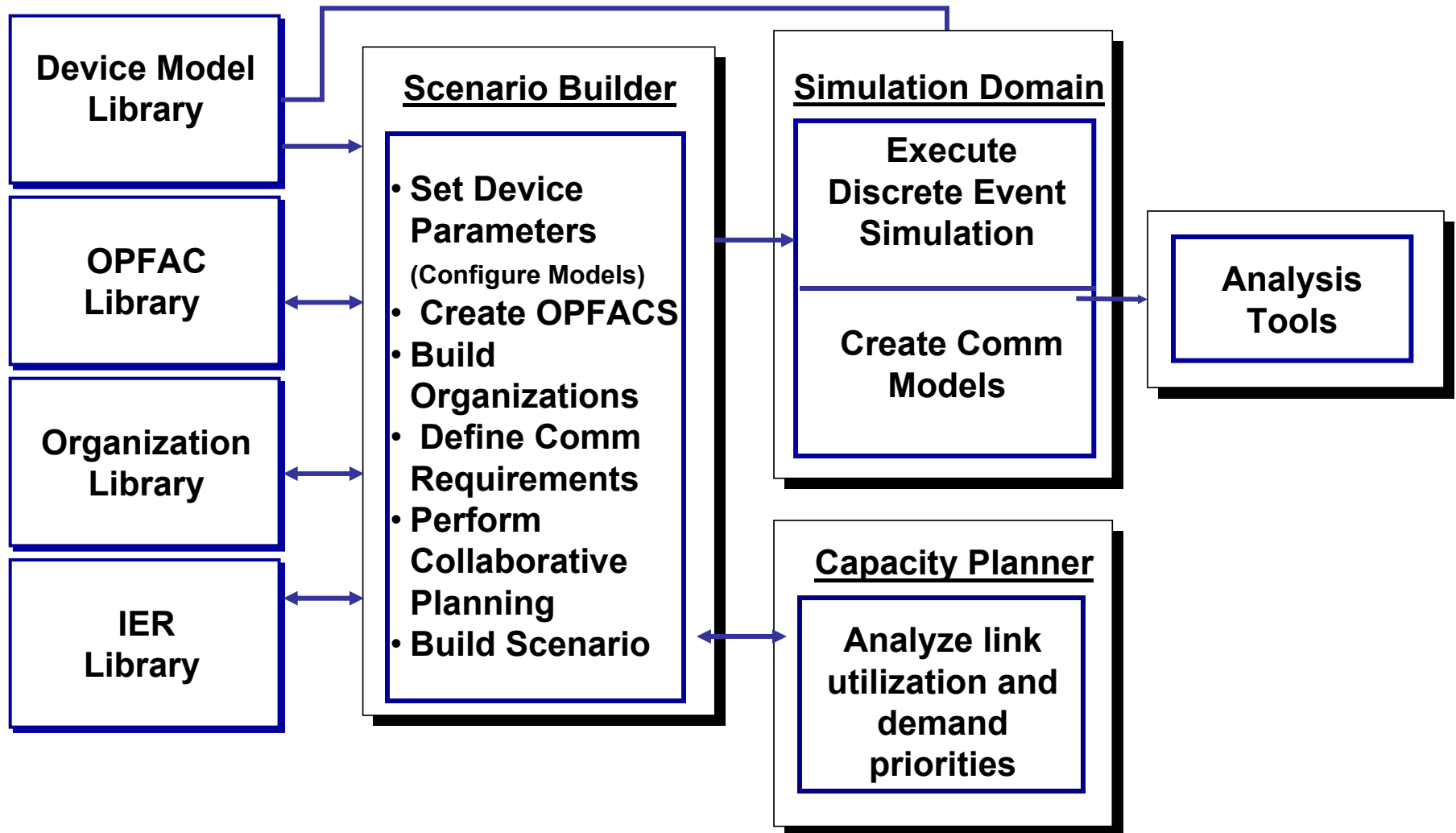
Network Warfare Simulation (NETWARS)

- Simulation Tool endorsed by the Military Communications Engineering Board (MCEB) as the Joint Services communications modeling tool of choice.
- Provides a common, validated simulation capability.
 - User interfaces, Joint model architecture, and device, protocol, and traffic model libraries.

NETWARS (continued)

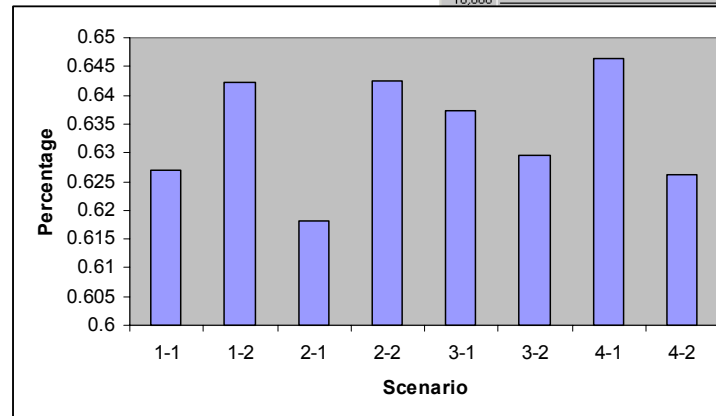
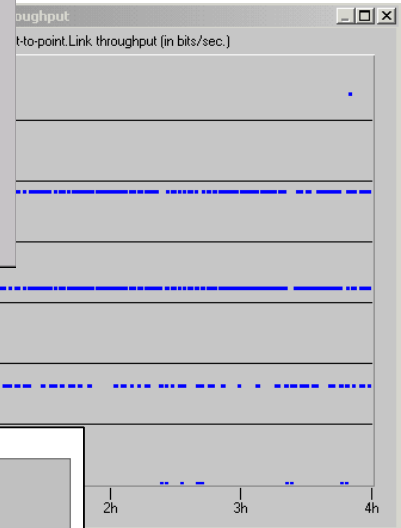
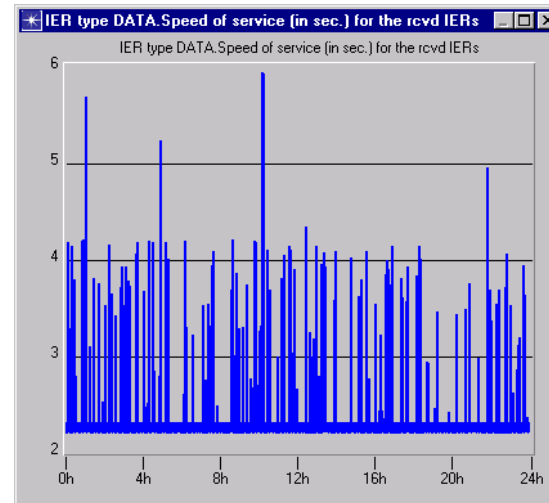
- Designed to extend M&S capability to the C/S/A's.
 - Conduct communications burden analysis at the JTF level (and below).
 - Perform rapid capacity planning
 - Evaluate impact of emerging technologies on battlefield communications
- Constructed using the Optimized Network Engineering Toolkit (OPNET)
 - Worldwide communications M&S environment.
 - Leverage models and core simulation software.

NETWARS Architecture



Sample Analysis MOPs

- IER Traffic Sent/Received
- Link Throughput
- Call Completion Rate
- Latency / Delays
- Blocking Probability



NETWARs MOPs

The Analysis Tools provide warfighter-specific IER Measures of Performance (MOPs)

MOP	Definition
IERs sent count	A cumulative count of IERs sent
IERs received count	A cumulative count of the received IERs
Blocking probability	The ratio of the number of IERs that were blocked at least once to the number that were sent.
Call completion rate	The ratio of the number of IERs of type “voice” <i>received</i> to the number of those sent.
Connection latency	The latency (IER_Sent – IER_Start) in establishing a connection.
End-to-end delay	The delay (IER_Rcvd – IER_Sent) computed for each received IER.
Grade of service	The percentage of IERs received within the IER_Perish time.
Message completion rate	The ratio of the number of <i>received</i> IERs of type “data” to the number sent.
Message error rate	The ratio of the number of <i>failed</i> IERs of type “data” to the number sent. This PM can be grouped by reason for failure
Message count	The total number of messages sent by a specific organization or OPFAC within the time period specified (e.g., 10 situation reports [SITREP] in 4 hours)
Number of Blocks for each IER sent	The number of times each IER was blocked
Perishability for received IERs	A cumulative count of the IERs received where the delay (IER_Rcvd – IER_Start) is greater than the IER_Perish time.
Speed of service	The delay (IER_Rcvd – IER_Start) computed for each received Information Exchange Requirement.

Hierarchical Model Development

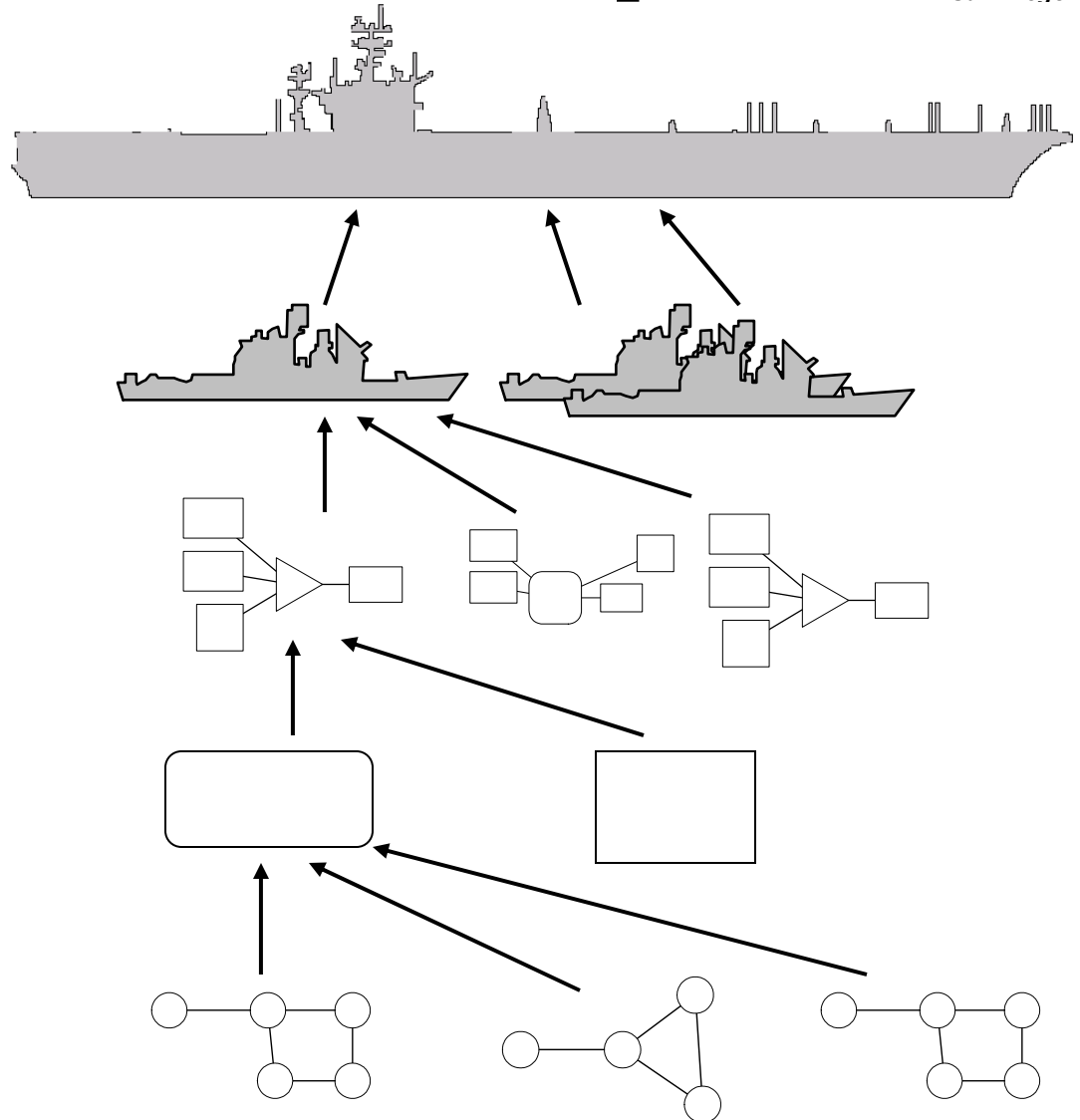
Deployment Models (e.g. STENNIS BG)

Organization Models (e.g. USS Lake Champlain)

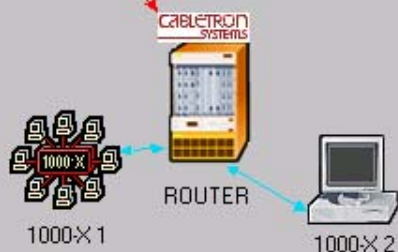
OPFAC Models (e.g. ISNS)

Device Models (e.g. CISCO 7500 router)

Function and Process models
(e.g. Ethernet)







(1000-X 2) Attributes

Type: workstation

Attribute	Value
[-] Application: Source Preferences	None
[?] [+ Application: Supported Profiles	None
[?] [- Application: Supported Services	None
[?] [+ Application: Transport Protocol Specification Default	
[?] [+ CPU Background Utilization	None
[?] [+ CPU Resource Parameters	Single Processor
[?] [- Client Address	Auto Assigned
[?] [+ Ethernet Parameters	Default (Host)
[?] [+ IGMP Host Parameters	Default
[?] [+ IP Host Parameters	(...)
[?] [+ IP Ping Traffic	None
[?] [+ IP Processing Information	Default
[?] [+ RSVP Protocol Parameters	(...)
[?] [+ Server: Advanced Server Configuration	Sun Ultra 10 333 MHz
[?] [- Server: Modeling Method	Simple CPU
[?] [- TCP Parameters	(...)
[?] [- Maximum Segment Size (bytes)	Auto-Assigned
[?] [- Receive Buffer (bytes)	8760
[?] [- Receive Buffer Usage Threshold (of RC 0.0	
[?] [- Delayed ACK Mechanism	Segment/Clock Based
[?] [- Maximum ACK Delay (sec)	0.200
[?] [- Slow-Start Initial Count (MSS)	1
[?] [- Fast Retransmit	Enabled
[?] [- Fast Recovery	Reno
[?] [- Window Scaling	Disabled

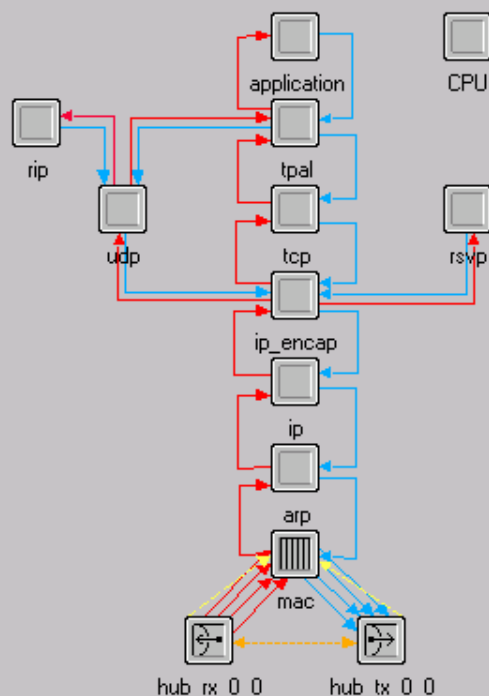
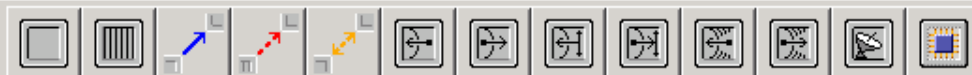
☐ Apply Changes to Selected Objects

☐ Advanced

Find Next

Cancel

OK



(tcp) Attributes

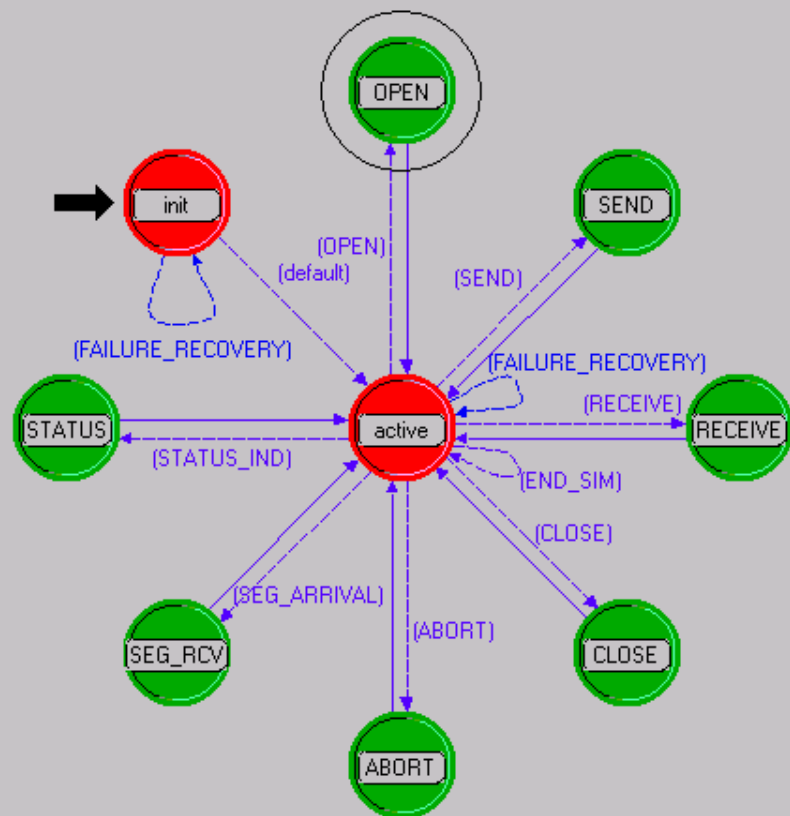
Attribute	Value
TCP Parameters	[...]
Maximum Segment Size (bytes)	Auto-Assigned
Receive Buffer (bytes)	8760
Receive Buffer Usage Threshold (of RC)	0.0
Delayed ACK Mechanism	Segment/Clock Based
Maximum ACK Delay (sec)	0.200
Slow-Start Initial Count (MSS)	1
Fast Retransmit	Enabled
Fast Recovery	Reno
Window Scaling	Disabled
Selective ACK (SACK)	Disabled
ECN Capability	Disabled
Segment Send Threshold	Byte Boundary
Active Connection Threshold	Unlimited
Nagle Algorithm	Disabled
Karn's Algorithm	Enabled
Timestamp	Disabled
Initial Sequence Number	Auto Compute
Retransmission Thresholds	Attempts Based
Initial RTO (sec)	3.0
Minimum RTO (sec)	1.0
Maximum RTO (sec)	64
RTT Gain	0.125
Deviation Gain	0.25
RTT Deviation Coefficient	4.0

Extended Attrs.

☐ Apply Changes to Selected Objects

Find Next

Cancel OK



* OPEN : Enter Execs

File Edit Options



```

1  /* Read the arguments to the OPEN call. */
2  if ((op_ici_attr_get (ici_ptr, "conn_id", &conn_id)
3      (op_ici_attr_get (ici_ptr, "local_port", &local_port)
4      (op_ici_attr_get (ici_ptr, "strm_index", &strm_index)
5      (op_ici_attr_get (ici_ptr, "rem_addr", &rem_addr)
6      (op_ici_attr_get (ici_ptr, "rem_port", &rem_port)
7      (op_ici_attr_get (ici_ptr, "local_addr", &local_addr)
8      (op_ici_attr_get (ici_ptr, "Type of Service", &type_of_service)
9      {
10     conn_failed = OPC_TRUE;
11     op_prg_log_entry_write (ll_loghnd1, "TCP OPEN failed -
12 }
13
14 /* First make sure that the maximum number of TCP Connections
15 if ((rem_port != TCPC_PORT_UNSPEC) && (max_connections != 0)
16 {
17     /* Maximum number of TCP connections has been reached.
18     /* Note that we always allow passive connection to be
19
20     /* Inform the application that the connection was not
21     if (op_ici_attr_set (ici_ptr, "conn_id", TCPC_CONN_ID_INVALID)
22         op_prg_log_entry_write (ll_loghnd1,
23             "TCP OPEN failed - unable to set connection
24
25     if (tcp_trace_active)
26     {
27         op_prg_odb_print_major (
28             "TCP process was unable to open a new conn
29             "The Active Connections Threshold has been
30     }
31 }
32 else
33 {
34     /* Connection threshold has not been exceeded or we are
35
36     /* If no stream index has been specified, pick a logic
37     if ((strm_index == TCPC_STRM_INDEX_UNSPEC) && (conn_fa
38     {
39         strm_objid = op_topo_connect (own_mod_objid, op_in
40         if (strm_objid == OPC_OBJID_INVALID)
41         {
42             tcp_no_stream_log_write ();
43             conn_failed = OPC_TRUE;
44         }
45     }

```

NETWARS Models

Systems and Networks



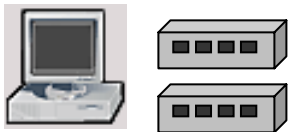
- CVN
- LHD
- DDG
- CG

- TCA Ships
- ISNS U/C (various versions)
- JSIPS-N
- FLBCST

- ADNS
- EC5G LOE Lab
- FORCENET LOE Platforms
- GiG

- ADMS
- NCTAMS
- NNOC

Devices



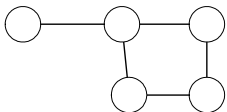
- Computers (Client/Server)
- Custom Workstations/Servers (PTW, IPL, etc).
- Routers (Cisco, Fore, etc.)
- Hubs (10baseT)
- Switches (100BaseT, 1000BaseT, etc.)
- Wired Links

- Link 11
- Link 16
- C2P
- EHF TIP
- Tactical Voice (KY68, STU-III, MMT, DNVT)
- Switched Voice (PBXs)
- TD1271 (DAMA)

- SATCOM Devices
- WSC 3/6/8 Radios
- USC 38
- TACINTEL
- IINMARSAT B Radio
- TACLANE
- KG 84/194

- Multiplexers (FCC100s, Timeplex Link 2/100s)
- Patch Panels
- BFEM Server
- Custom Workstations/Servers (PTW, IPL, etc).
- TCDL

Protocols and Processes



- Application Models (FTP, Rlogin, Email, etc)
- IP (v4, v6, & QoS)
- ATM
- AAL
- Token Ring

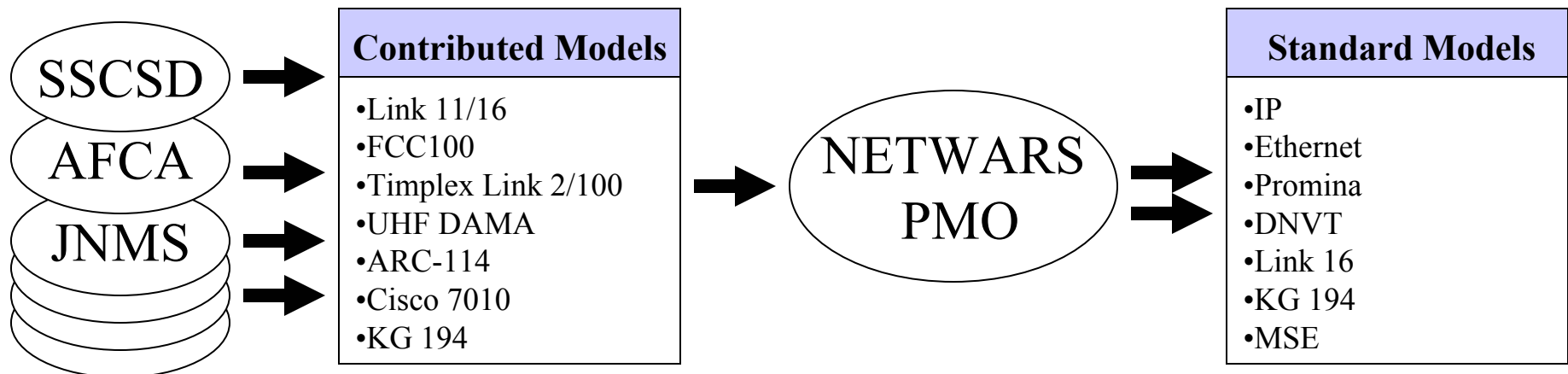
- Frame Relay
- Ethernet (10 Mbps, 100 Mbps, etc.)
- TCP
- UDP
- JRE (JREAP A)

- STANAG 5066
- DSRMA
- Dynamic TDMA
- MANET Protocols (AODV, OLSR, etc.)
- DAMA

- Routing Protocols (RIP, OSPF, BGP, etc.)
- 802.11
- Wireless Channels (propagation models)
- SATCOM orbits
- Mobility

NETWARS Model Acquisition

- The NETWARS model library includes both *contributed* and *standard* models.
 - Contributed models are provided by Service modeling agencies.
 - Standard models are certified by the NETWARS PMO as the preferred model for representation of a technology within NETWARS.
- Many standard models were originally contributed models.



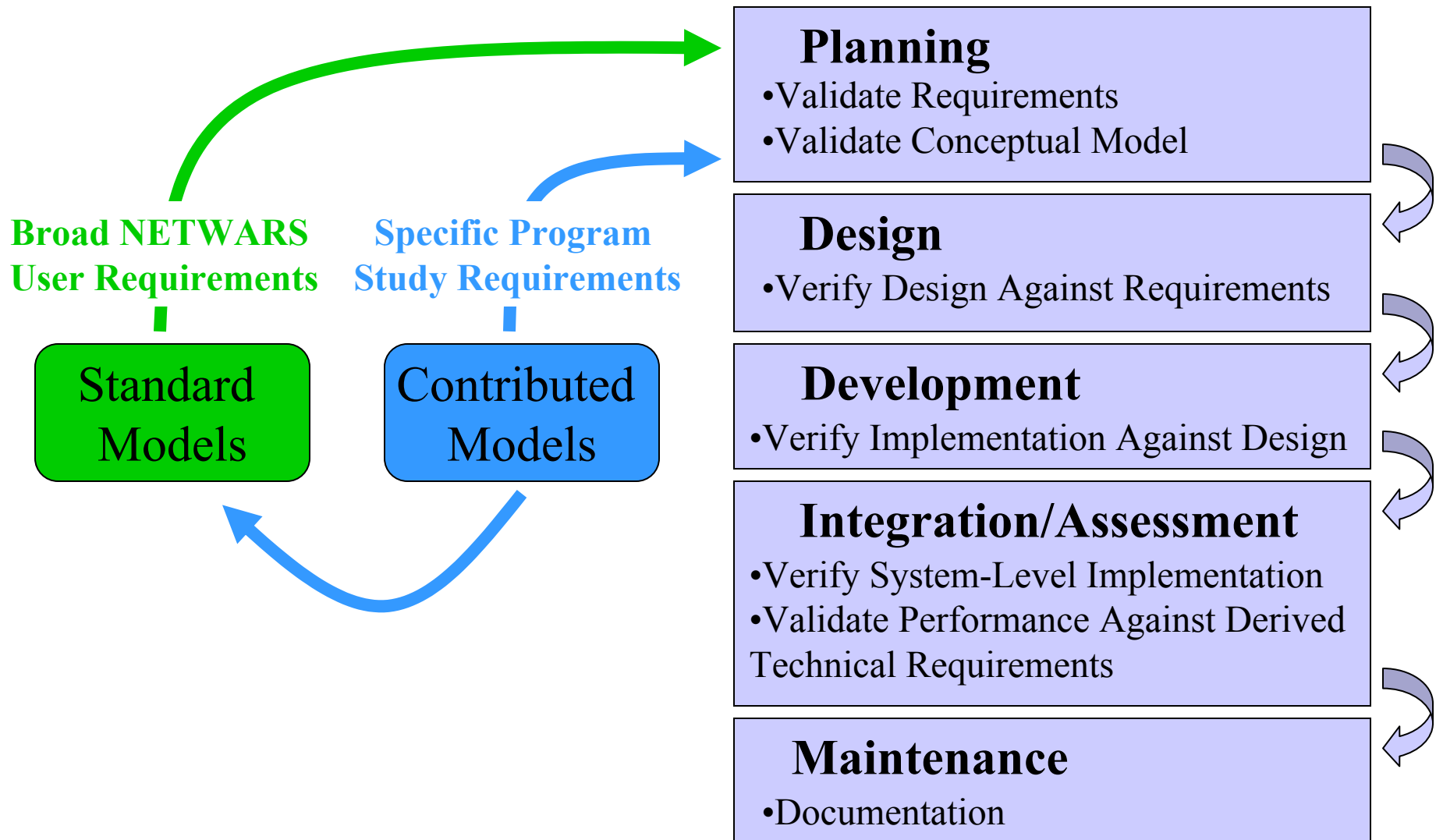
NETWARS Model Acquisition Approach

- Cost Effective
 - Leverages model development efforts from other programs.
 - Modeling each Joint DoD communications technology would be cost prohibitive.
- Promotes Model Interoperability
 - Standard protocol models (e.g. IP) provide a foundation for the development of fully interoperable device models (e.g routers, workstations, etc.).

NETWARS Model VV&A

- Contributed model acquisition approach poses VV&A challenges.
 - Contributed models are developed to meet specific assessment requirements.
 - NETWARS standard models are developed to meet a very broad set of study objectives.
 - Example – Steady state versus transient routing protocol assessments.
- NETWARS implements a multi-tiered V&V approach
 - Contributed model validation may occur several times as it is standardized.
 - Integration into the standard model library is treated as a new development effort.

NETWARS Model V&V



Navy NETWARS Model V&V Benefits



- Provided a foundation for a good model development process.
 - V&V is closely integrated with requirements definition, design, and documentation.
 - The V&V process has set the stage for model development process maturation (e.g. the use of UML for OOD).
- Promotes interoperability and reusability.
- Documentation at all modeling levels.

Standard Model V&V Case Study: Link 16



- SSCSD has developed an OPNET Link 16 Joint Tactical Information Distribution System (JTIDS) model.
 - Tactical message-based radio system.
- Originally developed as an OPNET model in June 2001.
- Enhanced capability through several M&S studies.
- Recent development direction from SPAWAR PMW 101/159
 - Lead Program Office for Link 16
 - Guided FY03 ONR model development requirements.
 - Enhanced model for prototype technology assessments (SHUMA, BCN, TSR)

Contributed Link 16 Model

- Navy model was contributed to NETWARS in 2003.
- V&V Inherited from ONR studies
 - Model was subject to several third party V&V tests.
 - Test scenarios were derived from use case requirements.

Validation Scenario	Description
C2P Traffic Generation – Cyclic, Single Message	Verifies the expected generation time of a single cyclic message type.
C2P Traffic Generation – Cyclic, Multiple Messages	Verifies the expected generated throughput of multiple cyclic message types.
C2P Traffic Generation – non-Cyclic Single Message	Verifies the expected generation time of a single non-cyclic message type.
C2P Traffic Generation – non-Cyclic Single Message	Verifies the expected generated throughput of multiple non-cyclic message types.
C2P Statistics – Sent/Received	Verifies proper sent/received statistics recording
C2P Statistics – Latency	Verifies proper sent/received statistics recording.
JTIDS Message Latency – Single Message, Varying TSBs.	Validates expected latency of a single message with varying Time Slot Block configurations.

Contributed Link 16 Model V&V (continued)

Validation Scenario	Description
JTIDS Message Latency – Many Messages, Multiple Time Slot Blocks.	Validates expected average latency of a large volume of messages with increased time slots. Also examines queue sizes.
JTIDS Time Slot alignment	Verifies proper operation of configured time slot blocks.
JTIDS Packing – Many Messages.	Validates expected throughput gains for each packing level.
JTIDS Error Tolerance – Medium BER	Validates expected message loss rate for a medium BER level.
JTIDS Error Tolerance – High BER	Validates expected message loss rate for a high BER level.
JTIDS Packing – Error Tolerance	Validates expected error performance for each packing level.
JTIDS Signal Propagation – No Collisions, Single Message	Validates expected signal degradation in the absence of collisions.
JTIDS Signal Propagation– Collision, Single Message, Mode 1	Validates expected signal degradation in the presence of a collision.
JTIDS Multinetting – Single Message Load, two transmitters, two nets, dedicated access.	Validates the expected performance of the pseudorandom frequency hopping capability for two nets.

- Many more...(~25 V&V Scenarios)

Link 16 Model Standardization

- Navy Link 16 model was selected for Joint NETWARS standardization in February, 2004.
 - Three different Link 16 models existed in the contributed model library.
- Standardization is considered a new development effort.
 - Additional requirements for user interfaces, network initialization modeling, and range extension modeling.
- Disseminated conceptual model to Joint user community for feedback.
- Next steps include model design and integration phases.

Summary

- NETWARS seeks to leverage significant levels of model development resources by acquiring models from distributed M&S Organizations.
- To ensure study validity and model interoperability, NETWARS implements a multi-tiered approach to model V&V.
 - Contributed models inherit original validity.
 - Focus on documentation of fidelity, functionality, and validity.
 - Standard models must undergo a more rigorous development process that includes a broad set of requirements.
- The V&V process was the foundation for the model development process in use within the Navy.